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The first part of this paper is a general introduction which defines programmed instruction, traces the history of the concept, and explains its basic ideas and terminology. Progress and problems in research and in evaluating programmed materials are also briefly considered, and a short selective bibliography is included in this first section. The second part of the paper discusses the application of programmed instruction to foreign language teaching, dealing in particular with the problem of specifying terminal behavior and the possibilities and limitations of effective use of programmed material in foreign language instruction. Some comments on current foreign language programmed materials are offered and some potential pitfalls in the field are identified. A brief consideration of cost and feasibility problems concludes the paper. (AR)

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A PRIMER OF PROGRAMMED INSTRUCTION IN FOREIGN LANGUAGE TEACHING

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A PRIMER OF PROGRAMMED INSTRUCTION IN FOREIGN LANGUAGE TEACHING

John B. Carroll, Harvard University

Carroll commence son article par une introduction générale relative au domaine de l'instruction programmée. Il en définit la terminologie et fournit une bibliographie de base. D'après lui les principes psychologiques de la programmation remontent aux études de B. F. Skinner sur le conditionnement opérant, dont il fait un bref résumé. Une discussion sur la graduation de la présentation, sur un enseignement "linéaire" par comparaison à un enseignement par "aiguillage", et sur d'autres sujets de recherches en cours, vient compléter cet exposé.

Dans une seconde partie, Carroll considère les possibilitiés d'application de l'instruction programmée à l'enseignement des langues étrangères. Il insiste sur l'importance d'une exactitude minutieuse, pour définir le comportement final requis. Bien qu'une gamme étendue des compétences linguistiques puisse être enseignée indépendamment par un cours programmé, le système normal sera probablement d'utiliser à la fois programme et professeur. Après un commentaire sur les programmes d'enseignement des langues étrangères déjà existants, l'auteur examine les défauts possibles de l'instruction programmée. Pour terminer, Carroll examine brièvement les questions posées par les prix de revient et la réalisation pratique.

Im ersten Teil seines Aufsatzes gibt Carroll eine allgemeine Einführung in das Gebiet des Programmunterrichts. Er definiert die Begriffe und liefert eine grundlegende Bibliographie. Er führt die psychologischen Grundlagen der Programmierung auf B. F. Skinners Arbeiten zurück, die er zusammenfassend darstellt. Eine Diskussion der „Stufendimensionen", des Problems geradliniger statt lateral verzweigter Lernstoffanordnung und anderer Gebiete der aktuellen Forschung beschließt den Teil.

Carroll untersucht dann die Anwendung der Programmierung im Fremdsprachenunterricht. Er betont, wie wichtig dabei eine präzise Bestimmung des erwünschten Zieles ist. Obwohl man mit einem programmierten Kurs eine große Reihe sprachlicher Leistungsbereiche unabhängig lehren kann, wird doch wohl die Kombination von Programm und Lehrer die normale Methode werden. Nach einer Betrachtung von bestehenden Fremdsprachenprogrammen untersucht Vf. die möglichen Fallstricke des Programmunterrichts. Mit einer kurzen Erörterung der Kostenfrage und allgemeiner Probleme der Durchführungsmöglichkeiten schließt der Artikel.

THE ORGANIZATION OF THIS PAPER

This paper has two major divisions: I. A General Introduction to Programmed Instruction, and II. Application of Programmed Instruction in the Teaching of Foreign Languages. In the first part, reference to problems of foreign language teaching will be only incidental, since the major purpose is to introduce the reader to programmed instruction as it has developed in the broad field of education. Much attention will be paid to the psychological principles underlying programmed instruction.

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*) Adapted from a work paper prepared for the Seminar on the Training of Teachers of Foreign Languages, University of Washington (Seattle, Wash., U.S.A.), August, 1962.

I. A GENERAL INTRODUCTION TO PROGRAMMED INSTRUCTION

WHAT IS PROGRAMMED INSTRUCTION?

Programmed instruction is a kind of teaching based on a carefully integrated psychological rationale. It has only a small number of defining characteristics, and it is important to keep these in mind in order to avoid confusion with a number of ideas (e.g., the notion of a "teaching machine") which have somewhat fortuitously come to be associated with programmed instruction. In what follows, we shall be defining not only programmed instruction but also such associated words as *program* (the detailed series of teaching materials which are prepared in advance and then used to teach a given skill or subject-matter) and *programmer* (one who prepares a program). We will try always to use the term *program* in its special sense rather than its general sense.

The defining characteristics of programmed instruction which we shall list are those characteristics which are *essential* to it. Instruction is not programmed instruction unless all three are present; what may appear to be a program is not really a program unless it has all three of these characteristics.

(1) Programmed instruction must be based upon an adequately detailed specification of the "terminal behavior" (that is, new skills, knowledge, or response tendencies) which the programmer desires to produce in students taught by the program.

(2) The material of instruction must be organized and presented in a carefully designed sequence of steps such that to the greatest extent possible, each step is made easier by virtue of the material learned in previous steps. As a corollary to this requirement, the steps must also be of an appropriate size for the student to master readily: a student may be ready to take a larger step if he has been properly prepared for it, and thus the program can lead to more efficient learning if sequencing and step-size have been properly attended to in preparing the program. In practice, it is found that the optimal size of step is considerably smaller than is usually assumed by inexperienced programmers.

(3) The student must have an opportunity to test his mastery of each critical step as he proceeds through the program. The program is so constructed that correct responses are promptly confirmed and the student is led to understand and correct wrong responses. When the material is properly programmed, simply exhibiting the correct answer will usually enable the student to do this.

Defined in terms of these three characteristics, it is evident that programmed instruction is fundamentally nothing new. It has been said that the methods of teaching introduced by Socrates have much in common with programmed instruction, and this is true if we assume that (1) Socrates had in mind a distinct series of "terminal behaviors" (knowledges, understandings, appreciations) which he wanted his students to achieve, (2) that he ordered the steps of his argumentation in something like the optimal way to promote those terminal behaviors on the part of his students, and (3) that he asked questions at all the right places to allow his students to test their achievements. The idea of breaking instruction down into small steps is at least as old as Descartes, who wrote that in studying any subject he found it useful to:

"... diviser chacune des difficultés ... en autant de parcelles qu'il se pourrait, et qu'il serait requis pour les mieux résoudre."

And further:

"...conduire par ordre mes pensées, en commençant par les objets les plus simples et les plus aisés à connaître, pour monter peu à peu, comme par degrés, jusques à la connaissance des plus composés; et supposant même de l'ordre entre ceux qui ne se précèdent point naturellement les uns les autres."

It is evident also that a classroom teacher *can* conduct his instruction in the manner of programmed instruction, and that programmed instruction *can* occur in the language laboratory. What the proponents of programmed instruction are fond of pointing out, however, is that traditional instruction often fails precisely because one or more characteristics of programmed instruction are absent. That is, a teacher can fail if he has not made an adequate analysis of the behavior he wants to teach, or if he fails to sequence his presentation properly, or if he fails to elicit and confirm trial responses of students at every critical point in the instruction. This last step is practically impossible in the conventional classroom: even in the so-called "recitation method," only a relatively small number of the responses of one's students can be explicitly tested in a class hour. Confirmation of student responses, however, is relatively easy to arrange for in the language laboratory.

It is because programmed instruction is so difficult to conduct in the traditional classroom that various special ways of conducting it have been devised.

In the first place, the concept of the "*program*" has developed. In practice, the program is a definite series of stimuli (usually visual, sometimes auditory, and they could even be tactual or olfactory if necessary) that are to be presented in some specified sequence to an individual student in such a way as to elicit active responses from the student and inform him of the appropriateness of those responses in the light of the goals of the program. Usually the program is divided into "frames"; each frame may present some new piece of instruction, and in any case calls for one response or a small number of responses from the student.

Secondly, various special *presentation devices* have come into use. Some programs are presented in the form of books: "programmed textbooks." In these, the "frames" are printed on successive pages in such a way that the student is encouraged to make a response to one frame and confirm it before reading the next frame. Other programs are printed on sheets of paper or continuous folded forms that can be used with specially designed "teaching machines" which expose the program frames one by one. Some teaching machines are even more complicated, accepting programs prepared on magnetic tape (for auditory stimuli) and/or film (single frames or sometimes even moving pictures). In principle, a *teacher* might be used as the presentation device for a program, but most programs are designed for use without a teacher, and in this sense they are said to be "self-instructional." Indeed, one of the advantages claimed for programmed instruction is that it saves the teacher from the ordinary repetitive routines, and thus allows more time for the creative aspects of teaching.

It is characteristic of most of the standard presentation devices that they allow the student to go at his own rate. Students may take various amounts of time to study or to respond to items, as long as eventually they make the desired responses. Presentation devices can of course be designed to require rapid responses if rapid

responding is specified as one aspect of the terminal behavior desired, but basically, the requirement that students should proceed step by step through a program, testing themselves as they go along, means that instruction has to occur on an essentially individual basis, in contrast to the conventional classroom procedures in which it is assumed that all students are following along with the teacher at identical rates. Since there is considerable variability in rates of progress, programmed instruction brings into sharp relief the administrative problem of how to deal with students of different degrees of learning ability. If it is intended that all students will eventually achieve the same level, and no more, the length of time allotted for instruction will have to vary for individual students; if it is intended that all studests will be under instruction for the same amount of time, more elaborate provisions (possibly including longer programs or a greater variety of programs) will have to be made for the fast learners.

A word should be said here about the error of assuming that there is a necessary connection between programmed instruction and "teaching machines." Even if we pass over the possibly unfortunate connotations of the term *teaching machine*, we must still stress that programmed instruction is only incidentally associated with teaching machines. The teaching machine is only one of the possible means of presenting programs; programmed textbooks or even "programmed instructors" may be equally effective. Indeed, some experiments have found that programmed textbooks are in certain circumstances more effective than teaching machines. On the other hand, it is almost inevitable that some kind of mechanical or electronic aid (such as the tape recorder) is desirable for the presentation of auditory stimuli; there need be no fear of the "teaching machine" if it actually aids in the presentation of a teaching program. It is the program, not the machine, that teaches.

It may be useful to conclude this section by mentioning a few examples of teaching procedures that are *not* programmed instruction, although some have thought them to be.

Most common among these is any procedure which merely elicits answers without being designed for teaching. A list of test questions to which the student is required to respond without being told whether his answers are correct will teach, if at all, only fortuitously. A similar list presented in such a way that the student is informed of the correctness of his answers after some considerable lapse of time (even a few minutes) will teach somewhat more, but not as effectively as when the information is given almost immediately after each response. Some "workbooks" are very close to programmed instruction, but others fall far short because they fail to pay attention to how they impart information, how they sequence the exercises, or how the student's answers are confirmed.

Even though a great deal of care may go into the preparation of a film, a tape, a television program, or even a lecture, these forms of instruction cannot be regarded as programmed if they do not require active response on the part of the student and confirm the correctness of his response.

Finally, a set of directions, even though they may evoke active response from students, is not necessarily programmed instruction. Merely telling a student to do a series of things will not necessarily teach him anything.

PROGRAMMED INSTRUCTION: A BIT OF HISTORY

Although the basic ideas of programmed instruction are not novel, the conscious formulation of these ideas and the actual realization of their potential were slow in coming. Various kinds of instructional machines have been offered to the public ever since 1809 when the first U.S. patent for an educational device was issued, but few if any of these machines were accompanied by instructional programs that incorporated all the essential features of programmed instruction in the contemporary sense. The psychologist Sidney Pressey did interesting work with "teaching machines" as early as 1924, but his programs were essentially lists of test questions and were not specially planned for teaching. Various instructional devices developed by the U.S. armed services in World War II incorporated some aspects of programmed learning, e.g., detailed task analysis, immediate confirmation of results, and shaping of behavior by successive approximations, but programmed instruction did not at that time become organized as a thoroughly integrated technique in education and training. Even the language laboratory methods that developed in FL teaching shortly after World War II cannot be regarded as representing a full-blown technique of programmed instruction, because the language laboratory tended to be looked upon chiefly as a place for drilling materials originally presented by a teacher in the classroom, and the idea of small-step programming was not adequately realized in the teaching materials.

Credit for arousing psychologists and educators to the possibilities of programmed instruction goes to B.F. Skinner, professor of psychology at Harvard University, who published in 1954 an article entitled "The Science of Learning and the Art of Teaching" (Skinner, 1954). Here Skinner set forth some principles of learning that could form the basis of programmed instruction, and reported early experimental work in the teaching of arithmetic by a programmed teaching device. But the idea of programmed instruction met with certain kinds of resistance: some were afraid that it would make learning too routine and uncreative, or that it would gradually replace the teacher; others saw practical difficulties in developing programs and reliable presentation devices. Skinner himself at first found considerable difficulty in getting either philanthropic foundations or commercial organizations interested in supporting his work. It was not until about 1958 (partly, no doubt, as a consequence of the first Soviet success with space flight) that the public awoke to the possibilities of programmed instruction as a means of securing better school learning. It was about this time, too, that commercial organizations began to see the profit-making possibilities in programs and devices for presenting them. Some of the first large-scale experiments in programmed instruction were in the training of industrial employees.

The leaders in programmed instruction have by and large been psychologists and other individuals whose convictions about the possibilities and values of programmed instruction have stemmed from their awareness of the psychological principles underlying it.

Among the books and other sources that are particularly valuable for getting acquainted with and keeping abreast of the whole field of programmed instruction are the following (including several publications specifically in the field of foreign language teaching):

Center for Programed Instruction, Inc. *Programs, '62: A Guide to Programed Instructional Materials Available to Educators by September 1962.* Washington: Govt. Printing Office, 1962.

Foltz, C.I. *The World of Teaching Machines.* Washington: Electronic Teaching Laboratories, 1961.

Fry, E.B., Bryan, G.L., and Rigney, J.W. "Teaching machines: an annotated bibliography." *Audio-Visual Communication Review*, Vol. 8, Supplement 1, 1960.

Fry, Edward, *Teaching Machines and Programmed Instruction.* New York: McGraw Hill, 1963

Green, Edward J. *The Learning Process and Programmed Instruction.* New York: Holt, Rinehart and Winston, 1962.

Holland, J. G., and Skinner, B. F. *The Analysis of Behavior: A Programmed Textbook.* New York: McGraw-Hill, 1961.

Lumsdaine, A. A., and Glaser, R. *Teaching Machines and Programmed Learning: A Source-Book.* Washington: Department of Audio-Visual Instruction, National Education Association, 1960.

Morrill, Charles S."Teaching machines: a review. *Psychological Bulletin,* 1961, 58, 363–375.

Morton, F. Rand, and others. *Programming of Audio-lingual Language Skills for Self-instructional Presentation:* selected work papers presented at the First Conference of Language Programmers, April, 1961, Ann Arbor, Michigan. Ann Arbor: Univer. Mich. Language Laboratory, 1962.

Rigney, J. W., and Fry, R. "Current teaching machine programs and programming techniques." *Audio-Visual Communication Review*, Vol 9, Supplement 3, 1961.

Ross, Wilbur, L., Jr., and others. *Teaching Machines: Industry Survey and Buyers' Guide.* New York: Center for Programmed Instruction, Inc., 1962.

Silberman, Harry F. *Self-teaching Devices and Programed Materials.* Santa Monica, Calif.: System Development Corporation, 1962. 20 p. (SP-Series No. 663)[1])

BULLETINS AND PERIODICALS

AID (Auto-Instructional Devices). Published monthly by INRAD, Educational and Training Methods Division, P. O. Box 4456, Lubbock, Texas.

Audiovisual Instruction. Published bi-monthly by the Department of Audio-Visual Instruction, National Education Association, Washington 6, D. C.

MLAbstracts. Issued by the Department of Foreign Languages and Literatures, Orange County State College, Fullerton, Calif.

Programed Instruction. Published bi-monthly by The Center for Programed Instruction, Inc., 365 West End Ave., New York 24, N. Y.

Journal of Programed Instruction, published monthly, by the Center for Programed Instruction, Inc., 365 West End Ave., New York 24, N. Y.

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[1]) [Editor's note] The following recent publications can be added to this list:
Margulies, S. and Eigen, L. D. *Applied Programmed Instruction.* New York, 1962
Coulson, D. E. *Programmed Learning and Computer Based Instruction.* New York, 1962
Lysaught, J. P. and Williams, C. *Handbook of Programmed Instruction.* New York, 1962

As of this writing, in 1963, it must be said, that the field of programmed instruction has not as yet found a settled place in American education, nor in American industry. While it has grown out of infancy, it is like a vigorous, but somewhat wayward and undependable child, equally likely to succeed admirably or fail miserably. It is too early to say to what extent American schools are going to accept programmed instruction and the accompanying paraphernalia of teaching devices. However, Ross and his co-authors in *Teaching Machines: Industry Survey and Buyers' Guide* (cited above) predict that the school year 1962–1963 will see fairly large-scale tryouts of programs in the larger and wealthier schools, particularly if results of experimentation in the year 1961–1962 are promising and reports are circulated. Nevertheless, they note that schools expect to use teaching devices only as supplements to classroom instruction, and they predict that shorter, "topical" programs keyed to existing textbooks will have greatest early success.

Actually, relatively few instructional programs are publicly available. The above cited *Programs, '62* was able to list only 122 programs, spread over many different subject-matters and grade levels, which would be available commercially by September, 1962[1]). These programs, to judge from the information and sample pages included in this publication, vary widely in length and quality. Not all of them truly conform to the definition of programmed instruction set forth here, for some programs are merely lists of questions. Only a handful (about 20 %) contained more than 4000 frames, and few programs were designed to occupy more than about 30 or 40 hours of a student's time (the equivalent of about 6 to 8 weeks of instruction in a high school). In the modern foreign language field, the following 10 programs were listed:

French:

Elementary French (Rickert and DuBois); General Programmed Teaching Corporation; 2510 frames; 18 to 23 hours to complete program. (No tapes)

German:

German A (Ellert); Encyclopedia Britannica Films, Inc.; 5050 frames with 12 7" tapes requiring 23 hours); 60 to 75 hours required to complete program.

Modern Language Series: German (Ventola and Wilson); TMI-Grolier; 3643 frames; 17 to 30 hours required to complete program. (No tapes)

Hebrew:

Modern Language Series: Modern Hebrew (Bloom and Smith); TMI-Grolier; 1900 frames; 15 to 25 hours required to complete program. (No tapes)

Russian:

Modern Language Series: Basic Russian Reading (Wilson and Ventola); TMI-Grolier; 1994 frames; 18 to 22 hours required to complete program. (No tapes)

Spanish:

Automated Spanish (Barcus); Denver Public Schools; 2016 frames; 20 hours to complete the program. (No tapes)

Spanish A (Sapon); Encyclopedia Britannica Film, Inc.; 6602 frames, with 22 7" tapes requiring 39 hours; 50 to 85 hours required to complete program.

Introductory Spanish (Sullivan); Encyclopedia Britannica Films, Inc.; 3276 frames with 7 7" tapes requiring 15 hours; 40 to 45 hours required to complete program.

[1]) The 1963 edition of this publication lists 352 programs, 21 of which are in modern languages.

Spanish U-3002 (Univox Institute, Inc.); Universal Electronics Laboratories Corp.; 2160 frames; 30 to 36 hours required to complete program. (No tapes)

Modern Language Series: Basic Spanish Reading (Wilson and Ventola); TMI-Grolier; 3400 frames; 17 to 30 hours required to complete program. (No tapes)

This is a good showing for the modern language field; in fact, in terms of the estimated number of instructional hours required, these ten modern language programs accounted for 13 % of the total number of instructional hours required for 72 programs in all areas for which data were given (programs in mathematics accounted for 49 % of the instructional hours). It is known that many other foreign language programmed materials are in preparation.

At this early stage in the history of programmed instruction we are not able to say much about the *evaluation* of programs. Research data on the actual effectiveness of programmed instruction are meager, unless one is willing to take at face value the fact many students do indeed successfully complete programs, thereby demonstrating at the very least their ability to respond successfully to the programmed materials. In 1961, a joint committee of the American Educational Research Association, the American Psychological Association, and the Department of Audio-Visual Instruction of the National Education Association released a statement advising prospective users how to make preliminary evaluations of programmed materials; the statement stressed the importance of examining the program "to determine what the student is required to do and whether the student's responses reflect the kind of competence which the educator wishes to achieve." But it also urged that users press publishers for information about "what students actually learn and remember from the program." Educational Testing Service in 1961 received a grant from the Carnegie Corporation to enable it to make methodological studies of how to evaluate programs, but a report cannot be expected until about 1963.

Although it can be argued that a low error rate is desirable, the mere fact that a program has a low error rate is no guarantee that it teaches anything, for it may be essentially a series of easy directions or highly prompted frames. One proposal for evaluating programs is to extract the "unprompted" frames (that is, frames for which the answers are not suggested by material in the frame itself) and administer them to students as a test of achievement after they have been through the program. In general, the results of such a test would be useful for evaluating the program, but if the unprompted frames still do not represent the terminal behavior set forth in the specifications for the program, the test will not provide evidence as to the degree to which the terminal behavior has been acquired. The solution is either to modify the frames in question before putting them into a test, or to construct an appropriate test of terminal behavior supplementary to the program in order to test transfer.

A major problem besetting the field of programmed instruction is the cost of creating and testing programs. Estimates of costs range from $4 to $25 *per frame,* so that an average sized program with, say, 2000 frames might cost anywhere from $ 8000 to $ 50,000. Obviously, creation of programs appears to be economically feasible only where high-volume sales can be expected.

FUNDAMENTAL IDEAS OF PROGRAMMED INSTRUCTION

We have said that programmed instruction has three essential characteristics: (1) it is based upon a precise analysis of the behavior desired; (2) it seeks to organize the instruction in the best possible sequence and in the best possible sizes of steps to produce optimal efficiency in learning; and (3) at every critical point in the program it provides the student with an opportunity to check his learning. We have also said that the warmest supporters of programmed instruction have been psychologists who are convinced of the soundness of the psychological ideas behind these characteristics of programmed instruction. It is not necessary to have a thorough knowledge of psychology in order to understand these ideas; they are simple and obvious once they are understood.

The fundamental psychological notion underlying programmed instruction is that it is possible to describe and classify the behavior of an individual, and cause consistent changes in it by certain definite procedures. This idea is based upon the study of overt, observable behavior – that is muscular movements of various kinds, including those producing speech – because this kind of behavior is easiest to deal with scientifically. Nevertheless, the psychologist has reason to believe that the principles underlying overt behavior are also applicable to such forms of covert behavior as "thinking" and "imagining," which are observable, if at all, only with difficulty.

All overt behavior may be classified under two major headings: *respondents* and *operants*. Respondents are reflexes of various kinds (like the knee-jerk reflex, the pupillary reflex to light, and the salivary reflex) which are largely involuntary and subject only to the kind of conditioning (called "classical conditioning") studied extensively by the Russian physiologist Pavlov. Operants, on the other hand, are responses (generally of the skeletal musculature) which are subject to another kind of conditioning, called *operant conditioning*, which occurs whenever the probability of the occurrence of a response is under the control of stimuli that *follow* the response in some contingent relationship. The contingent relationship is one in which such a stimulus *always* follows the response within a short time, or follows it more often or more promptly than pure chance would allow. Any stimulus that causes these responses to increase in probability, i.e., occur more frequently, is called a *reinforcer*.

In common sense language, any response that can be rewarded (reinforced) and that as a result tends to occur more frequently, is an operant. Most of the responses we are interested in teaching are *operants*, and in any case, the rationale of programmed instruction applies more directly to operant conditioning.

If one desires to change behavior, one way to do it is to wait for desired responses to occur and then reinforce, or reward them. But it is not always necessary simply to wait for responses that one can reward; one can "prompt" them in some way, either by presenting a direct stimulus for their occurrence, or by presenting some related stimulus which will tend to evoke them. (For example, one can cause the student to read a particular word, or think of a word that rhymes with a certain word.) Further, one can *shape* the behavior desired by first rewarding any response that has some resemblance to the desired response, then rewarding only responses that come closer and closer to the precise response desired (sometimes this process is calles "changing the topography of the response.")

Let us carry this analysis a little further to cover the process of forming *discriminative* behavior. By reinforcing only responses that occur in the presence of a certain stimulus, symbolized S^D, and withholding reinforcement from responses that may occur in the presence of another stimulus, symbolized S^Δ (read "S-delta"), it is possible quite readily to cause the individual to *discriminate* between S^D and S^Δ (if, of course, the discrimination is within his sensory capacities).

There are many other psychological concepts in the system of behavior analysis being drawn on here—a system that is largely the work of B. F. Skinner, but the few ideas presented above will serve most of our purposes in the consideration of programmed instruction. There are, to be sure, controversies about the adequacy of this system of behavior analysis, but it is doubtful that they concern matters that will affect the success of programmed instruction in any significant way.

As applied to programmed instruction, these psychological ideas can be translated into the following set of precepts: Decide what responses you want to teach. Arrange matters so that these responses, or approximations to them, will occur on appropriate occasions. Reinforce the desired responses until they occur with satisfactorily high probability. In order to teach a discriminative response, reinforce it in the presence of the S^D and withhold it when you present an S^Δ.

Most of the responses desired in programs teaching subject-matters like history, physics, etc., are *discriminative verbal operants*. That is, they are verbally-stated "answers" made to specific stimuli. Usually, too, they are operants that can be assumed to occur already in the repertoire of the student before he begins instruction. For example, in teaching the date of the Declaration of Independence we desire to have the student say "1776" (words he already knows) in the presence of the discriminative stimuli "Declaration of Independence, date?" Various means might be used to "prompt" such a response, e. g., by having the student read a poem about "The spirit of '76" or by pointing out the similarity of sound in inde*pend*ence and *seven*teen *seven*ty six. In programs for teaching foreign languages, the responses desired are also discriminative verbal operants, but they are in addition responses that (at least in their complete form) are not initially in the repertoire of the student. Hence, a considerable amount of "shaping" of these new responses must be done.

Programmed instruction assumes that the stimuli intended as reinforcers really act as reinforcers, that is, that they will operate to increase the probability of correct responses. For students who are already "motivated" to learn, any signal that a particular response is correct appears to act as a reinforcer. Furthermore, for these students, the reinforcing of correct answers tends to have a generalized effect in the sense that it reinforces their continued attention and effort. It has been found that students work more eagerly and enthusiastically on programs in which a large majority of their responses are correct than on programs in which they make many errors. And other things being equal, learning is more efficient in the former kind of program, if only because it takes students time to make errors and correct them.

At the same time, the reinforcements or rewards provided by the confirmations of correct responses in a course of programmed instruction do not of themselves "motivate" the student. The student must "want to learn" for some reason or other—either for "intrinsic" reasons (e. g., that the knowledge gained will be useful to him, or that he enjoys this kind of learning) or for "extrinsic" reasons—that he

must pass a requirement, that he must prove to himself his ability to learn, that he wants to get high grades, etc. Confirmations of correct responses are valuable to the student in three ways—first, they make him aware of general progress in learning; second, they give him knowledge of exactly what responses are correct; third (if he is "motivated"), they may also enhance the probability that on any future occasion when an appropriate stimulus is presented, the correct response will be made.

Programmed instruction should not, however, (we repeat) be expected to motivate a student who does not wish to learn or sees no utility in learning, unless special attention is paid to the kinds of rewards that are provided. The rewards constituted by confirmations of correct answers must sometimes be supplemented by more tangible rewards (money, tokens exchangeable for gifts, candy, etc., social recognition and approval). Such rewards have been found to be particularly necessary in the case of very young children (say, in the first grade).

It is observed that one of the ways in which the organization of programs can aid in motivating students is to provide clear sub-goals in the course of the program. A program organized in a series of units (say, 50 or 100 frames apiece), each with a definite set of objectives which are clearly part of those expected in the eventual terminal behavior, is more acceptable than one which presents a seemingly endless series of frames (often counted in the thousands) not organized in any obvious way. As a corollary of this, it is useful to inform students exactly what the subgoals of a unit are, so that they can recognize when they have achieved them and feel rewarded accordingly. It helps even to inform students concerning the organization of small sets of frames. For example, in teaching Mandarin Chinese by programmed instruction the writer informed the students at the outset that there are 4 tones in Chinese, and that besides recognizing the tones themselves, they would have to learn the numbers assigned to these tones, and the diacritical marks used to represent them. Only then did the program proceed to take up the tones one by one.

There are many other psychological considerations which should be understood if one is to make effective use of programmed instruction.

Efficient programming demands that the student should spend most of his time practicing the responses specified in terminal behavior, or in responses that actually lead up to this terminal behavior. He should not be allowed to make incomplete or partial responses (except such as are demanded by the program), and he should not spend his time making responses that are not included in terminal behavior or are only remotely relevant to it. If, for example, the desired terminal behavior is clear and accurate oral production of foreign words and expressions, the student must be required to make clear, audible responses while he is working through a program, not mere mutterings or sub-vocal responses. If the student is learning to spell, he should be required to say or write letters; he should not be required to perform irrelevant activities such as verifying that a particular word has 12 letters.

On the other hand, some of the responses specified in terminal behavior may be "passive" responses such as discriminations, meaning responses (identifying the meaning of a stimulus), and the like. In this case, it is not necessary for the student to be required on every occasion to make an overt demonstration of his response. If the student has been trained to respond, if only covertly, to every occasion requi-

ring a response, learning can be more efficient, as Roe (1962) has shown, by not requiring active responses. On the other hand, the making of active responses is to be encouraged during the experimental tryouts of a program, for in this way the programmer can easily find out which frames have too high an error count and judge whether they need revision.

Frequent testing of student response is advantageous because it continually requires the student to be alert. In the parlance of the analysis of behavior, it reinforces "observing behavior." It keeps the student listening or reading attentively.

The steps of a program (often called "frames") must be properly sequenced and adjusted in "size." In each step, we desire the student to make the maximum amount of progress possible toward the goal specified for terminal behavior. The intimate connection between proper sequencing and proper sizing of steps has already been mentioned. To recapitulate: if maximum efficiency of learning is desired, the programmer can help the student toward his goal by arranging the steps so that he is optimally prepared for each step, at the same time making the steps as large as possible without creating significant difficulties in learning. Some writers and practitioners in the programmed instruction field may have exaggerated the importance of making steps small. (For example, in an experimental program that has come to the attention of the writer, 29 steps are used to teach the pronunciation of the first letter of the Russian alphabet and the printing and writing of capital and lower case forms of it. This seems excessive in view of the considerable transfer that can be expected from properties of the first letter of the Roman alphabet, and on other grounds.) It is possible to "insult the intelligence" of students, or at least to try their patience. In practice, the programmer can safely err in the direction of making steps too large, for in experimental field trials he will quickly find which steps are too large, whereas he is unlikely to identify steps that are unnecessarily small, because students will perform them without difficulty, just as they will perform steps that are of an appropriate size.

Undue difficulty with a step is ordinarily "aversive" to a student; that is, it is unpleasant and unrewarding. A student who encounters too much difficulty, other things being equal, will be less enthusiastic about continuing. However, we have found that well motivated students will cheerfully accept difficulty if they are forewarned about it and have reason to believe that the challenge will produce a greater degree of learning.

Step size is particularly important in sequences where one is "shaping" behavior, for it is found experimentally (both with animals and with people) that the organism can progress only a certain amount of the way toward the final goal with each step, i.e., with each reinforcement.

Step size is also important in sequences where one is establishing stimulus-response "chains." A chain behavior is one where a series of acts A, B, C,..... are established so that A is the stimulus for response B, B is the stimulus for response C, etc. It is often desirable to use at least one step to establish each link in the chain, and principles of behavior suggest that these chains should be set up beginning at the end. Thus, if one wishes to set up the chain A – B – C – D – E, one starts by establishing the sequence D – E, because E (as the last member of the chain) ist presumably the most rewarding (that is, as the last member of the chain its emis-

sion is noted as signaling the completion or fulfilment of the act). Then one establishes C–D–E, then B–C–D–E, and finally A–B–C–D–E. This procedure justifies the use of the "backward build-up" in practicing foreign language sentences (the example is Mandarin Chinese, taken from Tewksbury's *Speak Chinese,* p. 46):

Háidz hěn tsūngming.
Syǎu háidz hěn tsūngming.
Neìge syǎu háidz hěn tsūngming
Nyànshùde neìge syǎu háidz hěn tsūngming.

Another principle to follow in deciding upon step size is that a composite response is easier when the separate parts of it have been previously mastered. One would hardly dream of asking a student to imitate a sentence like *Leurs enfants habitent ici* before he has had instruction in its separate phonemes, particularly those differing radically from anything in English. The organisation of steps is often a matter of arranging for learning of component parts of a composite response before the composite response itself is attempted; the size of step is then dictated by *how large* a component part can readily be mastered in one step by the learner. No definite rules can be given about this, although the programmer should have some notion about the size of the human memory span (about 7 separate well-learned units is the maximum for most people; 3 to 5 separate well-learned units is a much more comfortable span; less than this tends to be wasteful of time).

Finally, learnings are programmed in a series of separate steps in order gradually to withdraw stimulus support in the form of prompts and other artificial ways of evoking desired responses. This is called "fading" or "vanishing." For example, if one were teaching the spelling of the French names of the days of the week, one might give them first in the full form (*lundi, mardi, mercredi,* etc.), then with only their first syllables (*lun-, mar-, mer-,* etc.). then with only their first letters (*l-, m-, m-, j-,* etc.), and finally as simply a series of blanks to be filled in. At each of these stages, the subject is required to write the full response.

To a considerable extent, the breaking up of learnings into small steps in many contemporary programs (whatever the actual intent of the programmers may have been) seems to have the effect of controlling the time the student spends attending to a particular bit of learning. While it might be true that a student could learn the spelling of the French days of the week in one trial, requiring him to make responses in a series of variant steps forces him to spend more time on this learning and enhances his likelihood of retaining the learning. The same effect is achieved by requiring a student to solve a series of verbal problems covering the same concept. For example, in Holland and Skinner's program *The Analysis of Behavior,* a series of frames is devoted to applications of the principles of shaping. One of these is the following:

> "If the shot-put coach never *reinforces* unless the world's record is broken, he (1) *** using successive approximation; he (2)***have a criterion which, if reached, would direct him to provide differential reinforcement." (Frame 16–15; answers: (1) is not, (2) does.)

Essentially, this frame, like a number of others in the series, provides practice in determining under what conditions the concept of successive approximation applies; the actual responses (the verbal fill-ins) are not items of terminal behavior to be learned, but function as puzzle-solutions to force the student to spend time on the prob-

lem presented, that is, the problem of finding words to cause the statement to make sense according to criteria already learned. One of the best ways of forcing close and attentive reading of a prose passage is to omit a few words here and there to be supplied by the reader (sometimes called the "cloze" technique).

Thus, programmed instruction has at least some things in common with rote learning of the old-fashioned variety. It incorporates *planned* repetition, and it often supplies mnemonics or associational mediators. (For example, in a program purporting to teach the color codes of the electronic trade, *zero* is to be associated with *black* through the phrase "black nothingness," *one* is associated with *brown* through the phrase "one brown penny," etc.) Nevertheless, major inspiration for programmed instruction comes from concepts of behavior that are relatively new, and that are more precisely stateable than those of traditional theories of behavior. For this reason, it is believed more likely to be successful than instruction based on traditional theories.

RESEARCH ON PROGRAMMED INSTRUCTION

In what has preceded, a great many statements have been made as if they were backed up by solid experimental evidence. Most of the "solid experimental evidence" has accumulated in the field of animal learning; extrapolation to the case of the educated human being has been liberal. At the same time, research activity in the field of prgrammed instruction has been growing rapidly in the last four or five years. According to one writer, "If the extent of our understanding of the learning process were proportional to the rate of increase in articles on programed learning, most educational problems would be solved within the next decade." (Silbermann, 1962, p. 1). Unfortunately, as this same writer observes, "The most popular finding in the studies reported in this period is that no significant differences were obtained among treatment comparisons." (ibid., p. 8). "Beyond demonstrating that a carefully written set of materials will teach if a student will spend enough time studying them, we have little unequivocal evidence for principles of programmed instruction" (ibid., p. 9). It is therefore tempting to summarize the research done so far on programmed instruction with the statement that little of clear value has yet been accomplished, and that it does not seem to make very much difference how one prepares programs as long as care is expended. This conclusion, however, would be a little too hasty.

The degree to which one should control the exact sequence in which the student proceeds through a program has been the center of one of the major controversies in the field of programmed instruction. One point of view, associated most closely with Skinner and his followers, is that every student, regardless of his "ability" or prior training, should proceed through a program in a strictly linear fashion—that is, tackling every frame in order, once; proponents of this procedure try to create programs which allow all students to do precisely this without either undue difficulty or undue boredom. Another point of view, associated with the name of Crowder, argues that fast learners should be allowed to proceed through a program as rapidly as they can, skipping parts which they don't need, while learners who meet difficulties at any point should be given special remedial frames. Thus, students should be allowed to "branch" to parts of the program which are especially suited

for them. As yet, there is no clear experimental evidence [2]) to allow one to choose between the "linear" and the "branching" techniques, but it would seem that the flexibility of the branching technique could lead to superior efficiency in teaching; there is no need for a student to waste his time working through parts of a program which present materials he has already mastered. Furthermore, under some conditions a "cyclical" or "recursive" pattern may be more practical and efficient than a straight linear program; in these patterns, the student simply repeats certain segments of a program one or more times until a satisfactory degree of mastery is attained.

The present writer (Carroll, 1963b) has experimented with a cyclical organization of material which seems to have a number of advantages. Each frame is divided into three essential areas: "presentation," "question," and "answer," and the frames are organized into *loops* (typically of about 40 to 50 frames each). In a "familiarization" mode, the presentation of each frame is as follows: first, the "presentation" area is exposed, giving information or practice on a new step of the instruction; next, the question area is exposed (with the presentation area remaining exposed) posing a question or other task for the student; finally, after the student has made a response, the answer area is exposed (presentation and question areas still remaining exposed) in order to enable the student to verify his response. The initial presentation of each area can be accompanied by a short period of tape recorded auditory stimuli. In a "learning mode," the same sequence of events is used, but the presentation area and its accompanying tape recording are completely omitted. Typically, students work through a loop in the "familiarization" mode two or three times until they have worked their error count down to a satisfactory level, after which they review and check their learning by repeating the loop one more times in the "learning" mode (which actually functions more as a "testing" mode than a "learning" mode). The advantages of this system seem to be : (1) during the familiarization mode, frames can be made to be well prompted, and students can study reasons for their errors on the basis of material exposed in the "presentation" area, while during the learning mode, the identical material can be used as an unprompted frame (at the same time, the learner still has recourse to reduced prompts if he still needs them); (2) considerable economy in programming can be effected, since the same material is used repeatedly in different modes, and step sizes can be somewhat larger than in conventional linear programs; (3) students enjoy the challenge of reducing their errors on successive runs through a loop, and the attainment of a low error count in a loop is in itself rewarding for well motivated students.

Another controversy concerns whether the responses to be required of students in programs should be "constructed responses" (responses recalled from past experience or newly composed to fit the requirements of the problem) or simply "multiple choice responses" (choices among a relatively small number of presented alternatives). The answer depends partly upon the specification of the terminal behavior: if the programmer wants students to be able to recall or compose certain responses, such responses must be required at some point in the program, while

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[2]) At least two studies, however, have found that students allowed to branch learned just as well as a group forced to remain with a linear program, and took a shorter time. See Silberman (1962, p. 5).

if the programmer is chiefly concerned with teaching students to identify or label stimuli, or discriminate between them, the multiple-choice response is probably more efficient and time-saving. Furthermore, the teaching of multiple-choice responses is sometimes a stage which can simplify the teaching of the more demanding constructed response.

Some writers on programmed instruction have confused matters by assuming that the use of constructed responses is more closely associated with "linear" programs, while the use of multiple-choice responses is more closely associated with "branching" programs. If there is any association at all, it is a purely historical accident: during the development of programmed instruction, Skinner and his followers used chiefly constructed responses in linear programs, while Crowder and his followers used chiefly multiple-choice responses in his "intrinsic" or branching programs. One can find linear programs, however, which use multiple-choice responses or a combination of the two types; likewise, it is perfectly possible to require constructed responses in a branching program. (Whether the student branches, for example, may be made contingent upon whether he is able to construct the desired response in a particular frame.)

Rather clear experimental results have been obtained concerning the question of whether it is better to prompt a student's response before he makes it or to wait until he make it before confirming it. Surprisingly, the prompting procedure seems to make for better learning and retention in most of the experimental studies done. For example, if one is teaching a foreign language vocabulary by the paired-associate method, the prompting method consists of continuing to present both member of pairs like *chaise—chair, feuille—leaf, livre—book,* etc., but asking the subject to repeat the response terms *(chair, leaf, book,* etc.). The confirmation method consists of presenting just the stimulus member *(chaise, feuille, livre,* etc.) and giving the response term only after the subject has made a guess as to the response. If the experimental results are to be taken at face value, current programming techniques (which use primarily the confirmation procedure) are not as efficient as they might be. But it would be ill-advised to make an immediate change to a method relying exclusively on prompting, because the superiority of prompting may be limited to verbal associations; there are indications, too, that prompting is more valuable in the early stages of learning than in the later stages.

Research comparing programmed learning with conventional instruction is regarded as extremely difficult to perform because of the difficulty of holding constant the many variables which might otherwise affect the results. Time available, the quality of the program or of the conventional instruction, the presentational devices used, the Hawthorne or novelty effect, and the relevance of the criterion test are the major variables that have to be controlled. Most experimental studies have favored programmed instruction, even so, but different forms of programmed instruction take widely varying amounts of time. As yet, no definitive statement can be made as to whether programmed instruction will in the long run be more effective and efficient than instruction lacking one or more of the characteristics of programmed instruction. Regardless of the answer, it is possible that considerations of cost, availability of programs and programmers, availability of teachers, and the like will determine the extent to which programmed instruction will win acceptance in education.

II PROGRAMMED INSTRUCTION IN FOREIGN LANGUAGE TEACHING

OVERVIEW

This second part of the present paper deals with the special problems that may arise in connection with the application of programmed instruction in foreign language teaching. Among the questions that will be discussed are these: To what extent can FL teaching be aided by programmed instruction? Can a foreign language be taught by programmed instruction alone? To what extent is programmed instruction in a FL economically feasible? What special problems are there in preparing programs for FL instruction? What are the pitfalls of programmed instruction?

SPECIFYING TERMINAL BEHAVIOR

The answer to some of these questions depends first of all upon the specification of the goals of instruction, that is, the terminal behavior that one desires students to achieve. Specifying educational objectives is nothing that is completely unfamiliar to any teacher, but the need for such a specification is accentuated by the requirements of preparing programmed instruction.

The description of objectives, of course, depends partly on one's "level of aspiration." The level and kind of competence desired with a foreign language will have a strong influence upon the statement of objectives.

Whatever the case, detailed specifications of behaviors, skills, and knowledges desired in the "graduate" of a program are called for. Unfortunately, the drawing up of a truly thoroughgoing set of specifications is a large task. Ideally, an adequate linguistic description of the language being studied should be available; from this description one would select the particular items judged to be essential for achieving the level of language competence which is sought. One would list the phonological, grammatical, and lexical items which the student is expected to master. But there is more to the task than this. It is also necessary to specify the language *behaviors* desired in the student, that is, to state what mastery means in terms of behavior. "Mastery" of a phonological item might mean anything from "a technical knowledge of the phonetic classification of a phoneme" to "habitual and consistent use of the phoneme, with pronunciation like that of a native speaker, in free conversation as well as in formal speech"; one must decide what kind of mastery one seeks. Some items might be listed only for recognition rather than active use (e.g., the forms of the past definite in French). Ideally, one should plan the order in which the various ranges of meanings of lexical items should be introduced. Cultural meanings must be given careful attention, including the use of forms such as French *tu* and *vous*, various forms of greetings, expressions of time and tense, and many other items conditioned by the social situation. One must not forget, too, statements about the rate of speaking and understanding which the student is to attain.

The importance of preparing these specifications cannot be overemphasized, yet it can hardly be appreciated by a language teacher unless he actually tries his hand at program writing. He will find that the task of laying out and sequencing

the steps in the instruction demands a clear and definite set of specifications. Even if a program is based on an existing textbook or language course, it will be necessary to dissect, as it were, the intentions of the author in organizing his material, and often to clarify or regularize this organization. Skillful and successful programming depends upon the programmer's ability to keep in mind the kinds of responses that are desired in the student and the precise kinds of stimuli which are to be used to elicit these responses.

Fernand Marty, in his pamphlet *Programming a Basic Foreign Language Course* (1962) has provided an outline of the terminal behavior he desires for his program in French. According to him, "what should be the terminal behavior at the end of a basic course cannot be set arbitrarily; it has to be defined by experimentation." He classifies the components of terminal behavior under headings such as: "structures which the student must learn to handle without difficulty," "morphological items that be must learn to use," "optional liaisons that will be taught," etc. He specifies a vocabulary of 1200 words to be taught during the course, and requires that the student acquire an oral fluency of 150 syllables per minute and an audio comprehension of 200 syllables per minute. He insists, probably rightly, that the description of spoken French must be performed quite independently of the description of written French, and that the activities of speaking and reading French be kept sharply separate in the program.

The description of the terminal behavior must be carried down to the minutest detail. What does it mean to say that a student can handle a structure "without difficulty"? Take the use of the definite article with the partitive structure in French: handling this structure without difficulty could mean, for example, that at the rate of 150 syllables per minute the student can immediately shift from the affirmative structure using the definite article (*J'ai du pain*) to the negative structure where the definite article is not used (*Je n'ai pas de pain*). Or it might mean that in any situation where the student translates sentences requiring the partitive, like "I have some bread" and "I haven't any shoes," he will automatically use the definite article in the one case and omit it in the other.

The specification of the terminal behavior for programmed instruction is not in essence different from that which one makes, or should make, for any other form of instruction, but the need is simply more insistent. In the case of foreign language teaching, it entails not only the kind of detailed linguistic analysis of the target language that we have already described, but also contrastive analyses of source and target languages in order to identify what items may cause greatest difficulty in learning. It can also entail a rather special kind of linguistic analysis to search for sources of confusion in the target language. For example, what forms of the French verb are most likely to be confused (*[illegible]ut* with *fût*, *sens* with *sens*, etc.)?

Information on the terminal behavior intended by a program is also needed by prospective users. Just what does a program cover? What structures and vocabulary items are taught? The following statement of terminal behavior printed in the introduction to the program *Basic German Reading* published by TMI-Grolier is hardly adequate:

"The TMI-Grolier *Basic German* self-tutoring course teaches: the sound of the language; conjugation in present, past and future tenses of German verbs; the

syntax of the German sentence; recognition of simple patterns of article and noun declension in the singular; use of modal auxiliaries; the imperative mode; use of demonstrative adjectives and possessive adjectives; counting; and 150 useful German sentences."

One is not even told the size or the source of the vocabulary included in the course, and from this statement one would not be able without further study of the program to decide for what level of more advanced instruction the student would be prepared. (This is the sort of decision one can make for most elementary textbooks by a quick examination of the table of contents and the glossary.)

WHAT CAN BE TAUGHT BY PROGRAMMED INSTRUCTION?

From what little evidence is afforded by the few foreign language programs thus far developed, it would appear that a wide range of language competences can be taught by programmed instruction. Even without the use of auditory stimuli, lexical and grammatical material can be presented, and the student can attain at least an elementary reading knowledge of a language. With the full range of stimulation afforded by a combination of auditory and visual presentation devices, it should be possible to teach nearly every type of foreign language competence by programmed instruction.

At least one attempt has been made to develop a program of "total self-instruction," i.e., programmed instruction which dispenses with an instructor entirely. Fernand Marty (1962) reports having successfully developed such a program in French. After one year's trial of the program at Hollins College, he lists the following drawbacks:

1. Students missed the teacher-student relationship; from this fact, one concludes that if total self-instruction is to become accepted in schools and colleges, students will have to be weaned early from the teacher-student relationship.
2. "Reinforcement by a machine is not sufficient to provide high motivation." Students would have been better off if they had been periodically supplied with "public reinforcement."
3. The machine program failed to produce pronunciation as adequate as could be attained by a teacher supplemented by tape-recorded drills.
4. Too much time was consumed in detecting errors, and there was also a failure to detect errors with sufficient accuracy.
5. "A self-instructional program cannot provide for free expression."
6. Students felt the need of a book or other material to supplement the self-instruction in the language laboratory.
7. Students were dissatisfied with communicating only with a machine.

Actually, it is evident that few of these drawbacks would be irremediable. Some of them have to do with administrative and programming problems. Thus, it might be practical to wean students from teacher-pupil relationships earlier than is now done. One could easily give students more "public reinforcement" (e.g., by posting lists detailing student progress), and one could supply books or other material to supplement the teaching-machine program (because the use of the books would still be self-instructional). The time consumed in detecting errors might be reduced by improved programming techniques.

Only two or possibly three of Marty's points concern kinds of terminal behavior which may be difficult to teach by total self-instruction: (3), concerning pronunciation, and (5) and (7) concerning free expression and communicating with live persons. Marty admits that "it may be true that a very careful sequence of steps can train some students to discriminate with a high degree of accuracy between acceptable and non-acceptable phonological features," but claims that "for the vast majority of our students the process would be far too long and could not be fitted within a balanced program." (1962, p. 17)

The question thus remains: suppose we push self-instruction to the limit: how successfully could we produce terminal behavior which would be comparable to that produced by methods employing live instructors? This is a question that cannot be answered completely on the basis of present evidence. Probably the farthest advance into its exploration is the work of Morton (1960) and Lane (1961) who have experimented with automated teaching of foreign language phonology and grammar using principles of operant conditioning. Their work is not yet complete, and only tentative and somewhat contradictory conclusions can be drawn. In Morton's 1953–1954 experiment at Harvard (Morton, 1960), much success was attained, both in phonological and grammatical training. "Students emerging from the four sets in sound production exhibited an extremely good pronunciation of Spanish sounds and sound groups" (p. 19). "The degree of automaticity reached in the triggering and manipulation of verbal and physical responses to the acoustic signifiers [i.e., grammatical elements] was remarkably high in all students" (p. 22). The conclusions that one may draw from Lane's careful and rigorous experimental work are slightly more conservative: (1) that highly accurate discriminations among foreign language phones and between FL and native language phones can be taught very readily by appropriate techniques of discrimination learning; (2) that this rapid discrimination learning is based upon a history of prior experience with sounds—that the acquisition of the discriminations looks more like a process of discrimination transfer than a process of the shaping of completely new discrimination capabilities; (3) that the automated shaping of the *production* of FL sounds is enhanced when it has been preceded by a period of discrimination training, and that it tends fairly rapidly to arrive at some stable level; (4) unfortunately, the final level of production achieved is not always satisfactory. Nevertheless, it is possible to suggest a number of improvements upon Lane's techniques; for example, information about articulatory aspects of producing foreign language phones could be inserted into the program, for this is one sort of training that could probably be taught as well by a machine as by a live instructor (assuming that the machine is capable of both auditory and visual presentation).

Even without building a machine that will automatically evaluate students' pronunciation (an extremely difficult thing to do except in very limited areas of phonology, e.g., pitch), it is quite possible that programming techniques will soon be found that will teach accurate pronunciation of FL sounds in nearly all students. Morton's programming techniques seem generally adequate for the teaching of grammatical habits, and certainly knowledge of lexical items is a simple matter to develop by automated self-instructional devices. It is even possible to teach a dialogue by letting a machine take one part in the dialogue, while the

student learns to take the other. If sufficient ingenuity is expended, it will be found that there are few if any kinds of terminal behavior in foreign language teaching that cannot be programmed for teaching by automated, instructorless techniques. What we can expect of automated teaching is that it can develop the basic linguistic *competencies* that can make accurate comprehension and fluent, imaginative expression possible when the student is confronted with a live speaker of the foreign language he is studying.

There is, however, one caution that must be observed. The possibility exists, though it is small, that even terminal behavior that is well taught may become conditioned to the particular locale or circumstances of the teaching and hence may not be as strong or readily available to the student in another locale or set of circumstances. The phenomenon is similar to that which occurs when we find that we forget names of streets and public buildings except when we return to the city where we learned them. Foreign language behavior could become conditioned to a particular teaching machine. To avoid this, it is advisable to require the student to practice some of his learning away from the teaching machine or other presentation device being used. As yet, there is no experimental evidence concerning the seriousness of this problem; it may not be any more of a problem in programmed instruction than it is in conventional instruction. Or perhaps it would be a problem only in the case where an instructor or native speaker is never available to the student. The matter of how far a person would be able to go without any live instructor or competent speaker of the language is an interesting theoretical question; perhaps it is of increasing practical importance as the need grows for teaching "neglected" languages like Arabic or Hindi or for teaching languages in the grade school in times of teacher shortage.

In practice, however, we may expect that most use of programmed instruction occurs in a context where a teacher is available at least a part of the time. Programmed instruction is used in such a way as to relieve the teacher of some of the burden of presenting language lessons in the traditional manner. But it remains for the teacher to assist in student learning wherever the teacher can make a unique contribution. After his experience with "total self-instruction," Marty (1962) turned to a system of what he calls "partial self-instruction" in which students spend up to 90 per cent of their learning time on self-instruction and the rest of the time with a teacher, either individually, in small groups, or (occasionally) as a complete class. The individual and group meetings with the instructor are used for imparting general information, practice in free expression (carefully controlled within the limits of language items already learned), and the training and remediation of pronunciation. Marty reports no drawbacks in this system comparable to those he experienced with a system of total self-instruction.

The decision as to whether total or partial self-instruction is to be practiced may make a difference in the formulation or selection of elements to be included in the programmed instruction. For example, if the instructor is to be available for pronunciation training, much less emphasis on such training is needed in the self-instructional program. It would, however, be necessary to work out an appropriate balance between what is included in the program and what is planned for the teacher to do. From present evidence, it would seem that *discrimination* training in phonology can be done more effectively in self-instruction with a special

program of recorded auditory stimuli than with the teacher. Training in phonological production can also be done partly by self-instruction, but it must be supplemented by extensive work with the teacher. Similar balances between teacher and program responsibilities would have to be worked out in other phases of language teaching. If we take programming in a broad sense, this is no more than programming the entire course of instruction.

CURRENT PROGRAMMED MATERIALS IN FOREIGN LANGUAGE INSTRUCTION: SOME COMMENTS

A fairly good idea of the characteristics of current programmed materials in foreign languages can be gained by inspection of sample pages of these programs printed in *Programs '62*, cited above (p. 120). Even better is to examine the programs themselves. Facilities for the training of foreign language teachers and supervisors should include an up-to-date library of such programs as are available in either commercial or experimental form. It should also include specimens of at least those presentation devices that have gained widest circulation and acceptance, and students in the training program should familiarize themselves with the operation of these devices.

The aims of currently available programs vary widely. Some of them are designed only to help the student achieve a knowledge of a new alphabet (e.g., Cyrillic, Hebrew). Others are built ostensibly to teach a basic reading knowledge of a language. Several are concerned only with the phonetics or phonology of a language, and in this connection it is rather dismaying to note that some programs attempt to teach phonology *with no use of auditory presentation.* For example, a program called *Intrinsic Spanish (Sounds and Pronunciation: A Mathetical Course)* [3] makes the rather foolhardy attempt to teach Spanish sounds to anybody "with the ability to read and write English at the 9th grade level or above" solely by visual means (mainly, written text). The authors admit that the program produces only "approximations" and that, for example, only 50% of a typical class will acquire a proper Spanish *r*; nevertheless, in view of the availability and inexpensiveness of sound reproduction facilities it is indeed strange that these are not used in this program. Only three or four programs seem to have the full audio-lingual and reading-writing aims in view; the longest of these, of course, is Sapon's 6602-frame course in Spanish, which is said to require 50 to 85 hours for completion. Only a careful analysis of Sapon's specifications of terminal behavior would enable one to judge for what quantity of conventional instruction this might substitute. None of the programs concern themselves with intermediate or advanced instruction.

All the available programs in foreign language use an essentially linear programming technique; that is to say, there is no branching. Most of the frames require constructed responses, although multiple-choice responses are not entirely avoided. It is difficult to evaluate the size of steps; even though error rate is reportedly small the steps may actually be too small in some cases. We can only assure

[3] TOR Labs. Inc., 505 19th Ave., Tuscaloosa, Alabama, 1961.

ourselves that step size is probably not too large. [4]) It is also difficult to evaluate the sequencing of the materials either in the gross or in detail. Contemporary ideas concerning the sequencing of skills seem to have been followed; that is, phonology is taught before lexicon and structure, and lexicon is held to a minimum while basic structures are taught. There is some attempt to fit "pattern practice" within the framework of programmed instruction. In general, the available programs give the impression of being *adaptations* of materials already developed for textbooks or language laboratories. Of the programs known to the writer, only those developed by Morton and his associates at the University of Michigan seem to strike out in new directions to take advantage of principles of behavior control. The primary characteristic of Morton's work, as described in his *Language Laboratory as a Teaching Machine* (1960) is its separate consideration of disparate language skills, e.g., in phonology, the thorough training of discrimination skills before productive skills are attempted, or in grammar, the thorough training in "grammatical signals" before they are given lexical content.

Aside from data on error rates and times to complete programs, research data are not available for currently available foreign language programs on such matters as: performance of students on standardized tests of language proficiency; judgments or ratings of student performance by native speakers; retention after varying periods of time; success in attempting subsequent phases of language instruction; differential rates of progress for learners of different ages and different degrees of language aptitude; etc. Such data will be awaited with interest.

SOME POTENTIAL PITFALLS IN PROGRAMMED INSTRUCTION IN FOREIGN LANGUAGES

1. *Overzealous claims.* Programmed instruction has been heralded as the "wave of the future" in education. Its proponents tend to argue its merits first of all on theoretical grounds. They praise it because it conforms to a superior analysis of behavior and of the means by which that behavior may be modified or "controlled." [5]) We will not truly be able to decide the merits of programmed instruction until we have the results of wide-scale field trials. Such field trials have become possible only

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[4]) It is of some interest, perhaps, to note that the per-frame times for the linear FL programs listed in *Programs '62* vary widely, but they are all under one minute. For example, from data supplied in this source one can estimate that the average per-frame time for Sapon's Spanish A program ranges from 27 to 46 seconds.

[5]) The word *control* as used by behavioral scientists has probably been misunderstood in some quarters. Behavioral scientists do not seek to "control" behavior in the sense of "pulling the strings" like a puppeteer. They do not pretend to be "Big Brothers" arbitrarily dictating the behavior of students. The notion of "control" is better thought of as akin to the notion of "guiding" or "arousing" behavior. If appropriately designed, a learning situation can guide or arouse the formation of new response tendencies—tendencies which the student usually wishes to acquire in any case. Matters can be arranged in such a way that these new responses will *come under the control of certain stimuli.* The control, then, is to be exercised by stimuli (spoken words, printed problems, etc.) rather than by the teacher or anyone else who sets himself up as an arbitrary dictator.

recently with the development of a number of programs that appear to pass preliminary criteria of acceptability. In the meantime, one hears claims of seemingly miraculous successes with programmed instruction. In their zeal, proponents of programmed instruction have sometimes been guilty of a strange inconsistency. Out of one side of their mouths they warn us that research studies comparing programmed instruction with conventional instruction are extremely difficult to perform with adequate experimental controls, and that even with adequate controls the results can easily be inconclusive. Out of the other side of their mouths they extol the successes of programmed instruction by citing figures intended to show that pupils are much more successful with programmed instruction than with "conventional instruction." In the foreign language field, there seem to be no *published* reports of this kind, although there undoubtedly will be in the near future. These reports need to be subjected to the closest possible scrutiny, raising such questions as: How did learning times for the same content or subject matter compare? Were the same content and objectives used in the two procedures? How good was the conventional instruction with which programmed learning was compared? Did experimental and control groups have equal opportunity to learn? Even if efficiency in *learning* was superior for programmed instruction, was *retention* also superior? Were student attitudes toward programmed instruction more favorable than toward conventional instruction? Etc.

2. *Inefficient programs.* In the absence of hard data, it is difficult to support the charge that many present programs are inefficient, but inspection of these programs suggests that they are. Many very elementary points are belabored *ad nauseam,* or the instructions as to the mechanics of proceeding through a program get unnecessarily tedious. (How many times does one have to be told that one is to select the French word, not the English one, or that one is to repeat after the voice on the tape, etc.?) This seems to be due in part to the principle of the minimal step which has circulated among programmers. In order to make a program *efficient,* steps must be of *optimal* size; perhaps they must even be of different sizes for students of different language aptitude. Programmed instruction will not succeed, in foreign languages or any other subject, if it tends to waste the time of students. Nor will it be fully accepted if the format of programs is such that an unnecessary amount of paper and equipment is needed. As said elsewhere, it is believed that programmers in foreign languages should start with the assumption that students can treat a language program in a reasonably intelligent way, and that points of difficulty should be allowed to emerge from informal tryouts. Points of difficulty in foreign language instruction are more likely to arise from inadequate explanation or inadequate *preparatory* practice for the introduction of a new learning than from inadequate breaking down of a particular learning into small units. Actually, there are advantages in presenting relatively large units at one time (e. g., several sentences of a dialogue, or a series of contrasting linguistic structures) for the student is enabled more readily to perceive the structure of such larger units and to practice them as wholes.

3. *Overefficiency in foreign language programs.* It would be a strange paradox, but nevertheless a conceivable eventuality, if programmed instruction in foreign languages turned out to be "too good." If it regularly produced students with perfect native accents, startling fluency in speaking, high proficiency in reading and writing, and

decided empathy for a foreign culture, one can realize the educational pandemonium that might result. The educational system might not be able to absorb such students, or they might be to some extent less acceptable in a foreign country than if they exhibited a suitably non-native accent. One solution for this unlikely eventuality would be to modify one 's specification of the terminal behavior (e. g., to acquire a cultivated but not native accent); another would be to revise the foreign language curriculum to accommodate students with high proficiency in a language.

4. *The cost of programmed instruction.* All the evidence available at present indicates that the cost of programmed instruction will initially be greater than of conventional instruction. The pitfall for programmed instruction is that the industry may fail to recognize the need for reducing programmed instruction costs to a minimum compatible with sound program development. At the same time, competition in the industry may force some of the smaller enterprises out of business, with the consequent loss, it may be, of the results of some good work and good thinking.

5. *The difficulty of educational research in the context of programmed instruction.* The difficulty of doing educational research in the context of programmed instruction is admitted. Unless one is studying merely a small number of variables for the purpose of refining programming methodology, it is difficult to set up adequate experimental settings or laboratories for the purpose of evaluating the technique. Unless careful longitudinal studies of student progress under programmed instruction are made and widely circulated, it will be next to impossible to provide "labels" for programs that really say what a program can accomplish in terms of the relevant content. The pitfall for the field is that too little money may be available to support such ventures.

6. *Overstandardization.* Prospective purchasers of programs and of presentation devices are being told to "wait and see" – either not to use any programmed instruction at all, or to use only materials and devices that show high likelihood of becoming standardized and widely accepted. This advice has the function of protecting purchasers against materials and devices that will rapidly become obsolete, but if accepted too widely may have the unfortunate effect of freezing development at some mediocre level. The widespread standardization now taking place, for example, in the use of certain kinds of programmed texts and machines for presentation of only *visual* material may retard the development of properly standardized audio-visual programs and presentation devices. The concentration on strict linear programs, with standard frame size, may be another evidence of overstandardization.

COST AND FEASIBILITY PROBLEMS

Among the factors that would have to be considered in judging the cost of programmed instruction in a foreign language are the following:

1. The basic unit costs of programs as fixed by publishers or distributors. The unit costs of the foreign language programs listed in *Programs, '62,* where given, range from $ 10.00 for TMI-Grolier's 1994-frame program in Basic Russian Read-

ing to $ 229.25 for Sapon's Encyclopedia Britannica Films 6602-frame program "Spanish A" accompanied by 22 7" tapes. Publishers should, however, be asked for separate prices for the components of their programs (programmed texts, tapes, teachers' manuals, tests, etc.) inasmuch as it may be possible to reduce costs by re-using some components and locally duplicating tapes (if publishers permit).

2. The length of programs in terms of either number of frames or instructional hours, considered also in terms of the amount of content covered. Obviously, a program that takes 5000 frames and an estimated 45 hours to attain a certain educational objective is more costly and inefficient than one that achieves the same objective in 3000 frames and an estimated 25 hours. Furthermore, if the per-pupil cost of programmed instruction materials for the first 45 hours of a course is, say, $ 10.00 and the per-pupil cost of conventional instruction materials for the remaining 35 hours of an 80-hour course is only $ 2.00, one would institute programmed instruction only if the efficiency of programmed instruction were very much greater than that of conventional instruction. Very few data are yet available to enable one to judge costs of programmed instruction in foreign languages in these terms. A useful exercise for a FL-supervisor would be to examine various programs in foreign languages available and analyze probable costs in comparison to conventional instruction, with due regard for the estimated levels of proficiency likely to be attained after any given amount of time. It would be useful for such a person to refer to data on program costs supplied on page xii of *Programs, '62,* where it is stated: "In general, the cost of programmed instructional materials seems to be considerably higher than of textbooks in terms of equivalent content covered."

3. The unit cost of presentation devices that may be necessary or desirable. Programmed texts, of course, do not require presentation devices other than themselves. The printed components of many other programs are ordinarily prepared in such a way ("down-the-page") that effective use requires a simple "teaching machine" for successive presentation of frames and frame areas, including spaces for the student to write his answer. In order for the program to be reusable, it must be possible for the student to write his answer somewhere else than on the program itself, for example, on a separate "answer tape." Among the machines available for presenting "down-the-page" programs printed on unbound sheets are: The Koncept-o-Graph machine ($ 32.00) with a separate answer tape, and the Min-Max machine ($ 20.00), which does not provide a separate answer tape. These machines, of course, could be used with a large variety of programs—not only for foreign languages but for many other courses. It is not considered necessary here to discuss costs of tape recorders and other components of language laboratory systems that may be used for presenting audio-visual programs.

Some experimental programmed materials in foreign languages may require the use of rather special audio-visual presentation devices. Little information can be given concerning the probable cost of these devices. However, the following audio-visual devices are among those listed, pictured, and described in the recent publication *Teaching Machines: Industry Survey and Buyers' Guide* (1962):

Dorsett Electronics Model 834 (approximately $550)
Eastman Kodak Mentor Model I ($200 for basic unit; "synchronized sound planned as a further accessory")
Graflex Audio-Graphic ($750)
Hamilton Research Associates Auditutor ("$200 to $500")
Kalart Soundstrip (price unknown)
LaBelle Industries Teleguide (price unknown)
Lectron Corporation of America Mark I ($445)
Visual Programing, Inc. Model Phi Sound/Sight Programed Instruction Presenter (under $400).

Most of these devices are of very recent introduction; prices may decrease if sales prove to be of sufficient volume.

One factor that may have to be considered in the choice of audio-visual devices would be the cost of program *production* (as contrasted with program creation). The production and copying of multiple-channel tape recordings (in which one or more channels may be used for control signals) and of film-strips with special control spots may be difficult and costly unless inexpensive devices are provided to facilitate this work. This is a problem, of course, only if foreign language teachers or supervisors intend to prepare program material themselves.

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